

WHAT IS CLAIMED IS:

1. A method for the formation of an organic coating on a substrate comprising:
- 5 providing a substrate in a vacuum;
- providing at least one vaporized organic material comprising at least one component from at least one source, wherein the vaporized organic material is capable of condensing in a vacuum of less than about 130 Pa;
- providing a plasma from at least one source other than the source of the vaporized organic material;
- 10 directing the vaporized organic material and the plasma toward the substrate; and
- causing the vaporized organic material to condense and polymerize on the substrate in the presence of the plasma to form an organic coating.
2. The method of claim 1 wherein the step of causing the vaporized organic material to condense and polymerize comprises:
- 15 causing the plasma to interact with the vaporized organic material and form a reactive organic species; and
- contacting the substrate with the reactive organic species to form an organic coating.
- 20 3. The method of claim 1 wherein the step of causing the vaporized organic material to condense and polymerize comprises:
- condensing the vaporized organic material on the substrate in the presence of the plasma to form reactive species that polymerize to form the organic coating.
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4. The method of claim 1 wherein the substrate is in close proximity to a radio frequency bias electrode such that the substrate is exposed to a radio frequency bias voltage.
5. The method of claim 4 wherein the radio frequency bias voltage is sufficient to provide the coating with a density that is about 10% greater than the density of the major component of the organic material prior to vaporization.
6. The method of claim 4 wherein the radio frequency bias voltage is sufficient to provide the coating with a density that is about 50% greater than the density of the major component of the organic material prior to vaporization.
7. The method of claim 1 wherein the vaporized organic material comprises vaporized mineral oil.
8. The method of claim 7 wherein the plasma comprises a carbon-rich plasma and the vaporized organic material comprises vaporized dimethylsiloxane oil.
9. The method of claim 7 wherein the coating formed comprises a layer of a carbon-rich material, a layer of dimethylsiloxane that is at least partially polymerized, and an intermediate layer of a carbon/dimethylsiloxane composite.
10. The method of claim 1 wherein the step of providing a plasma comprises generating a plasma in a vacuum chamber by:
injecting a plasma gas into a hollow cathode system;
providing a sufficient voltage to create and maintain a plasma within the hollow cathode system; and

maintaining a vacuum in the vacuum chamber sufficient for maintaining the plasma.

11. The method of claim 10 wherein the hollow cathode system is a hollow cathode slot system comprising two electrode plates arranged parallel to each other.
12. The method of claim 11 wherein the hollow cathode slot system comprises a first compartment having therein a hollow cathode tube, a second compartment connected to the first compartment, and a third compartment connected to the second compartment having therein the two parallel plates.
13. The method of claim 12 wherein the step of injecting a plasma gas comprises injecting a carrier gas into the first compartment and a feed gas into the second compartment.
14. The method of claim 13 wherein a plasma is formed from the carrier gas in the first compartment.
15. The method of claim 13 wherein a plasma is formed from the carrier gas and the feed gas in the third compartment.
16. The method of claim 15 wherein the feed gas is selected from the group consisting of saturated and unsaturated hydrocarbons, nitrogen-containing hydrocarbons, oxygen-containing hydrocarbons, halogen-containing hydrocarbons, and silicon-containing hydrocarbons.

17. The method of claim 10 wherein the hollow cathode system comprises a hollow cathode tube.
18. The method of claim 10 wherein the hollow cathode system comprises:
5 a cylinder having an outlet end;
a magnet surrounding the outlet end of the cylinder; and
a tube having a leading edge, wherein the tube is positioned inside the cylinder and recessed such that the leading edge of the tube is in the plane of the center line of the magnet.
- 10 19. The method of claim 18 wherein the magnet is made of a ceramic material.
20. The method of claim 18 wherein the tube is made of a ceramic material.
- 15 21. The method of claim 1 wherein the plasma is formed from an inert gas.
22. The method of claim 21 wherein the coating formed is a single layer of organic material.
- 20 23. The method of claim 21 wherein the polymerized organic material comprises a layer of multiple organic materials.
24. An organic coating on a substrate preparable by:
providing a substrate in a vacuum;
25 providing at least one vaporized organic material comprising at least one component from at least one source, wherein the vaporized organic material is capable of condensing in a vacuum of less than about 130 Pa;

providing a plasma from a source other than the at least one source of the vaporized organic material;

directing the vaporized organic material and the plasma toward the substrate;

5 causing the plasma to interact with the vaporized organic material and form a reactive organic species; and

contacting the substrate with the reactive organic species to form an organic coating.

10 25. The organic coating of claim 24 which is one layer of a single organic material.

26. The organic coating of claim 24 which is one layer of multiple organic materials.

15 27. The organic coating of claim 24 comprising multiple layers of different organic materials.

28. The organic coating of claim 24 which is a silicone coating.

20 29. The organic coating of claim 28 wherein the silicone coating has a density of at least about 1.0.

30. The organic coating of claim 24 which is polymerized mineral oil.

25 31. The organic coating of claim 24 which has a density that is at least about 10% greater than the density of the major component of the organic material prior to vaporization.

32. The organic coating of claim 31 which has a density that is at least about 50% greater than the density of the major component of the organic material prior to vaporization.
- 5 33. A non-diamond-like organic coating on a substrate comprising an organic material comprising at least one major component, wherein the coating has a density that is at least about 50% greater than the density of the major component of the organic material prior to coating.
- 10 34. The non-diamond-like organic coating of claim 33 which has substantially the same composition and structure as that of the starting material.
35. The non-diamond-like organic coating of claim 33 which is one layer of a single organic material.
- 15 36. The non-diamond-like organic coating of claim 33 which is one layer of multiple organic materials.
37. The non-diamond-like organic coating of claim 33 comprising multiple layers of different organic materials.
- 20 38. The non-diamond-like organic coating of claim 33 which is a silicone coating.
39. The non-diamond-like organic coating of claim 38 wherein the silicone coating has a density of at least about 1.0.
- 25 40. The non-diamond-like organic coating of claim 33 which is polymerized mineral oil.

41. A jet plasma apparatus for forming a coating on a substrate comprising:
a cathode system for generating a plasma;
an anode system positioned relative to the cathode system such that the
5 plasma is directed from the cathode system past the anode system and toward
the substrate to be coated; and
an oil delivery system for providing vaporized organic material
positioned relative to the cathode system such that the vaporized organic
material and the plasma interact prior to, or upon contact with, the substrate.
42. The jet plasma apparatus of claim 41 wherein the hollow cathode system is a
hollow cathode slot system comprising two electrode plates arranged parallel to
each other.
- 15 43. The jet plasma apparatus of claim 42 wherein the hollow cathode slot system
comprises a first compartment having therein a hollow cathode tube, a second
compartment connected to the first compartment, and a third compartment
connected to the second compartment having therein the two parallel plates.
- 20 44. The jet plasma apparatus of claim 41 wherein the hollow cathode system
comprises a hollow cathode tube.
45. The jet plasma apparatus of claim 41 wherein the hollow cathode system
comprises a point source.
- 25 46. The jet plasma apparatus of claim 45 wherein the point source comprises:
a cylinder having an outlet end;
a magnet surrounding the outlet end of the cylinder;

a tube having a leading edge, wherein the ceramic tube is positioned inside the cylinder and recessed such that the leading edge of the ceramic tube is in the plane of the center line of the magnet.

5 47. The jet plasma apparatus of claim 41 further including a radio frequency bias electrode in close proximity to the substrate to be coated.

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10 48. The jet plasma apparatus of claim 41 wherein the anode system is an adjustable anode system located substantially below the path the plasma travels when in operation.

49. The jet plasma apparatus of claim 41 wherein the oil delivery system comprises an atomizer for forming droplets of the organic material prior to vaporization.

15 50. A hollow cathode system comprising:

a cylinder having an outlet end;

a magnet surrounding the outlet end of the cylinder; and

a tube having a leading edge, wherein the tube is positioned inside the cylinder and recessed such that the leading edge of the tube is in the plane of the center line of the magnet.

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